We thank the anonymous reviewer for reviewing our manuscript and for providing helpful comments. Below we respond (in bold type) to the reviewer's comments (in normal type).

In this study, intensive measurements of soil water content from 5 m profile in a watershed were made during 5 years. Spatial pattern and temporal dynamics of soil water content have been explored. The authors found some interesting results and further highlighted that evapotranspiration is the dominant mechanism of water flow under both wet and dry conditions on the Chinese Loess Plateau. The paper is well written and easy to understand. I think it worth publication in HESS. However, I think authors can further improve the expression of some equations and some other minor issues need to be addressed before it can be accepted.

Thanks very much for these comments.

Lines 17-18: this is too general and may not be true. Please be more specific regarding the knowledge gap please.

We will rewrite the knowledge gap: *<u>"The spatial and seasonal patterns in soil moisture and the processes controlling them in loess landscapes are not well understood."</u>*

Line 45-49: This was also observed in the study area before at the transect scale for different land uses. In addition, the associated patterns will be depending on what indicator (SD or CV) is used for characterizing spatial variability (https://doi.org/10.1016/j.geoderma.2011.02.008).

We will include this reference: *<u>"The spatial heterogeneity of soil moisture usually varies with the average field-, hillslope-, transect-, and catchment-scale wetness (Hu et al., 2011; Western et al., 2003)."</u>*

Line 56-57: spatial pattern of soil moisture was found to be dominated by topography in a watershed on the Chinese Loess Plateau (https://doi.org/10.1016/j.jhydrol.2013.10.002). I would encourage authors to discuss dynamics and mechanisms of soil moisture by drawing a bit more literature from the study area.

The linked reference concluded that topographic properties, particularly the convergence index, significantly influenced soil moisture patterns in a catchment located in Saskatchewan, Canada, but played a negligible role in a catchment located on the Chinese Loess Plateau. The authors attribute this to the limited impact of lateral flow and the dominant role of vertical water movement in the semi-arid loess catchment.

We will include this reference in Introduction section (P3, Line 80): "*…even at the end of the growing season when the catchment was at its driest state. <u>By contrast, in a semi-arid catchment</u>*

***in the Loess Plateau, China (annual precipitation 437 mm), Hu and Si (2014) reported that the convergence index had negligible impact on soil moisture patterns in both wet and dry conditions.*"**

Line 76 and Line 95: please see my comments above. The most relevant literature on the Chinese Loess Plateau should be discussed for yielding knowledge gaps.

We will discuss more studies conducted in the Chinese Loess Plateau and rewrite the knowledge gaps: "…that may result in distinct soil moisture patterns. *Several studies have examined the spatial variability of soil moisture and its complex links with potential controlling factors on the Loess Plateau (Gao et al., 2011; Gao et al., 2016; Qiu et al., 2001; Yu et al., 2018). However, the relatively sparse observation sites and short monitoring period, combined with the highly seasonal local climate, make the spatial and seasonal patterns difficult to detect. Furthermore, the selection of the controlling factors can sometimes be subjective (Hu et al., 2017), with the result that we lack a systematic assessment of local and nonlocal controls on soil moisture patterns in this region."*

Line 134: Authors please comment why 1 mm rather than 2 mm was used for soil texture analysis.

In loess-based soils, the fraction of "very coarse sand" (with diameter limits from 1 mm to 2 mm) is generally very small or even negligible. This is supported by Wang et al. (2013), who reported that only a small number of sand particles were retained on the 1 mm mesh during soil sieving. Considering this, we made an adjustment to our soil texture measurement by using 1 mm soil sieving, which is a widely accepted practice in various studies conducted in the loess plateau. For instance, Hu et al. (2011), Jia et al. (2013), and Wang et al. (2011) have also adopted the same approach in their studies.

Line 155: too many abbreviations to remember, how about using s, m, d and y, respectively, to represent site, month, depth and year?

We appreciate the reviewer's suggestion to use more straightforward abbreviations. While these abbreviations s, m, d, and y can sometimes have multiple meanings, such as "second", "month", "day", and "year", respectively. This could lead to confusion, particularly when they are used in combination, for example, θ_{smd}. To avoid such ambiguity, we decide to continue using i, j, and k as abbreviations for "site", "month", and "soil depth". The primary purpose of using mathematical notation with abbreviations is to aid readers in understanding the calculation process, while in the results and discussion sections, we will make sure to provide full names of variables alongside the abbreviations to clarify the variables being discussed. For example, in Figure 2, we will provide the caption as *"… the average volumetric soil moisture for hillslope ($\theta_{hillslope,jk}$) and gully sites ($\theta_{gully,jk}$)"*. Similarly, in Figure 6, we will provide the caption as "*… average volumetric soil moisture in the top 100 cm of soil for SE-facing slope ($\theta_{SEf,j0-100}$), NW-facing slope ($\theta_{NWf,j0-100}$), and gully sites ($\theta_{gully,j0-100}$)*". Readers do not need to continuously remember which variable is represented by which mathematical notation, as the full names of the variables are provided for reference.

Line 161-169: I would like to consider to embody soil moisture of different sub-regions or the whole area of the watershed in equation (2) by introducing another variable. The same may apply to eq. (3). As it is, the equations are not mathematically robust enough although they are understandable. You need to explain why you are specifically interested in 0-100 cm, does it have anything to do with your finding that soil moisture at 0-100 cm is more temporally dynamic?

In equation (2) and equation (3), we will introduce "θ_{gully}", "$\theta_{hillslope}$", "θ_{NWf}", and "θ_{SEf}" to represent the soil moisture for gully, hillslope, NW-facing slope, and SE-facing slope sites, respectively:

"Because of the much higher soil moisture in the gully than on the hillslopes, in each month j and soil depth k, we also determined average soil moisture for all gully ($\theta_{gully,jk}$) and hillslope sites($\theta_{hillslope,jk}$), and for the NW- ($\theta_{NWf,jk}$) and SE-facing slopes sites ($\theta_{SEf,jk}$) separately:

$$\theta_{location,jk} = \frac{1}{N}\sum_{i=1}^{N} \theta_{ijk} \quad , \qquad (2)$$

where N is the number of gully (N=25), hillslope (N=64), NW-facing slope (N=30), or SE-facing slope (N=34) sites. We also determined the average soil moisture over 0-100 cm depth (5 soil layers) for the gully ($\theta_{gully,j0-100}$), NW-facing slope ($\theta_{NWf,j0-100}$), and SE-facing slope ($\theta_{SEf,j0-100}$) in each month j:

$$\theta_{location,j0-100} = \frac{1}{5}\sum_{k=20}^{100} \theta_{location,jk} , \qquad (3)$$

"

We are more interested in soil moisture over 0-100 cm depth indeed because there are more pronounced seasonal changes in the soil moisture within these soil layers. We will clarify this after equation (3): *"We specifically focused on soil moisture in the top 100 cm, as our analysis in seasonal variability (see section 4.1) indicated that soil moisture within this depth range exhibits more pronounced seasonal dynamics."*

Line 179: it is a bit confusing as k refers to soil depth above (e.g., 20 cm, 40 cm, …), but here it represents the rank of the layer from top (e.g., 1, 2, …). Please be sure they are referring to the exact same thing. Can you use eq. (4) to calculate? In my mind you just need to make k more flexible, it can be a certain depth or a certain layer. The same to Eq (6), can you please use one equation to explain it clearly? To me, the main difference will be whether the whole watershed or just part of the watershed are involved in calculation. So please try to use as small number of equations as possible.

We will unify "k" to refer to soil depth (e.g., 20 cm, 40 cm, …) consistently throughout the manuscript. The relevant equations (equations (3), (5), and (8)) will be adjusted to employ the notation "$\frac{1}{5}\sum_{k=20}^{100}$ ".

We will merge equations (5) and (6) into a single equation to minimize the number of equations used: *"…<u>Then we similarly determined the average seasonal deviation in soil moisture over 0-100 cm deep soils for the gully ($\delta\theta_{gully,j0-100}$), NW-facing slope ($\delta\theta_{NWf,j0-100}$), and SE-facing slope ($\delta\theta_{SEf,j0-100}$) separately in each month j:</u>*

$$\delta\theta_{location,j0-100} = \frac{1}{N}\sum_{i=1}^{N}(\frac{1}{5}\sum_{k=20}^{100}\delta\theta_{ijk}) \quad , \tag{5}$$

<u>where N is the number of gully (N=25), NW-facing slope (N=30), and SE-facing slope (N=34) sites.</u>"

Line186-192: why these needed to be calculated, how does this relate to the main objective you want to target? They need to be better clarified.

The trimmed standard deviation (we will change it to the "regular" standard deviation based on the comments from reviewer#2) of θ_{ijk} at each site and depth (σ_{ik}) was used to quantify the seasonal changes in soil moisture. Then we identified the depth at which σ_{ik} exhibited its maximum value or converged to a small value, allowing us to determine the depths at which the seasonal changes in soil moisture were largest or collapsed. In the revised manuscript, we will re-clarify this: "*<u>We also quantified the seasonal changes in soil moisture at each site and depth (σ_{ik}) using the standard deviation (SD) of θ_{ijk}. We identified the depth of maximum σ_{ik} to determine the depth at which the seasonal changes in soil moisture were largest. We also identified the depth where σ_{ik} converges to a small value to determine the depth at which seasonal soil moisture changes collapse. We defined the collapse threshold as the minimum σ_{ik} plus 10% of the difference between the maximum and minimum σ_{ik} at each site. The shallowest depth at which σ_{ik} was less than this threshold was defined as the depth at which the seasonal changes collapse.</u>*"

Similarly, In Line 205-207, the trimmed standard deviation (which also will be changed to "regular" standard deviation) of θ_{ijk} at each month and depth (σ_{jk}) was used to quantify the overall spatial variability in soil moisture across the hillslopes. Then we used σ_{jk} and $\theta_{hillslope,jk}$ to explore the relationship between spatial variability and soil moisture conditions across the hillslopes. We will add more clarification in the revised manuscript: *"The spatial variability of the soil moisture in month j and soil layer k, across the hillslope, σ_{jk}, was described by the SD of θ_{ijk}. <u>We used σ_{jk} and $\theta_{hillslope,jk}$ to explore the relationship between spatial variability and soil moisture conditions across the hillslopes.</u>"*

Line 198 and Line 203: you need try to find a way to embody slope in the equation as I commented above. Why δ' rather than δ is used here?

We will incorporate $\theta_{hillslope,jk}$ in this equation, which has been calculated in equation (2) as recommend by the reviewer: *"…thus the spatial deviation in soil moisture for hillslope site i, soil depth k, and month j, $\delta'\theta_{ijk}$ was computed as*

$$\delta'\theta_{ijk} = \theta_{ijk} - \theta_{hillslope,jk} \quad , \tag{6}$$

where $\theta_{hillslope,jk}$ is the average soil moisture for the hillslope sites in month j and soil depth k,

as described above."

δ was used in the section "3.2.1. Seasonal variability in soil moisture" to represent the "seasonal deviation" in soil moisture. For instance, $\delta\theta_{ijk}$ indicates the deviation in the soil moisture θ_{ijk} from the annual average for that site and depth. Therefore, δ' was introduced in the section "3.2.2 Spatial variability in soil moisture at hillslope scale" to represent the "spatial deviation" in soil moisture. For instance, $\delta'\theta_{ijk}$ indicates the deviation in the hillslope soil moisture θ_{ijk} from the hillslope average for that month and depth.

Line 224: why not other topographic properties such as slope?

Thanks for this suggestion. We have tried this in the data analysis process, but the soil moisture and slope are not correlated well in our study area. Here is the Spearman correlation result:

Month	**Correlation coefficient**	**p-value**	**p-range**
1	**-0.194028418**	**0.127403437**	**p>0.05**
2	**-0.189708141**	**0.136225605**	**p>0.05**
3	**-0.174299155**	**0.171477654**	**p>0.05**
4	**-0.169402842**	**0.183973073**	**p>0.05**
5	**-0.119719662**	**0.349104022**	**p>0.05**
6	**-0.049731183**	**0.698038435**	**p>0.05**
7	**-0.124663978**	**0.329446406**	**p>0.05**
8	**-0.020593318**	**0.872499752**	**p>0.05**
9	**-0.18327573**	**0.150207591**	**p>0.05**
10	**-0.156586022**	**0.219785145**	**p>0.05**
11	**-0.197148618**	**0.121308046**	**p>0.05**
12	**-0.179723502**	**0.158375369**	**p>0.05**

Line 232: why not try cos(aspect) as it looks like a good indicator for soil moisture (https://doi.org/10.1016/j.jhydrol.2017.05.054)

Thanks for this suggestion. We have tried the correlation analysis between soil moisture and cos(aspect), but they are not correlated well in our study area. Here is the Spearman correlation result:

Month	**Correlation coefficient**	**p-value**	**p-range**
1	**0.028705837**	**0.822916352**	**p>0.05**
2	**0.023521505**	**0.854535517**	**p>0.05**
3	**-0.021505376**	**0.866896968**	**p>0.05**
4	**-0.130760369**	**0.306197794**	**p>0.05**
5	**-0.012480799**	**0.922579921**	**p>0.05**
6	**0.039458525**	**0.758281893**	**p>0.05**
7	**0.018097158**	**0.88786502**	**p>0.05**

8	**0.12562404**	**0.325712633**	**p>0.05**
9	**0.002208141**	**0.98640505**	**p>0.05**
10	**0.084149386**	**0.511067736**	**p>0.05**
11	**-0.178379416**	**0.161550421**	**p>0.05**
12	**0.029473886**	**0.818254664**	**p>0.05**

Instead a correlation test, we linked the difference in monthly soil moisture and the difference in incoming solar radiation between the NW-facing and SE-facing slopes to determine the effect of aspect on soil moisture (Figs. 7 and 9).

Figure 6c: title from y axis is missing. Can you please add measurement error for each graph？

We will add a title for the y-axis as "*P, PET, and P-PET [mm/month]*". Error bars will also be added on each panel. We will also fix a few minor errors for the monthly P and PET calculation, resulting in slight discrepancies for the result. It is important to note that this correction does not affect our conclusions.

Line340-342: this is not that obvious visually. I would suggest authors to improve figure 7 by also making sure they are readable in white and black.

If only white and black colors are used to represent dry and wet conditions, we would miss capturing the seasonal changes in spatial variation (smaller spatial variation from May to July, larger spatial variation from October to March, which are now depicted with lighter and darker colors, respectively). What we can do is add an aspect layer as a base map to help support the findings.

Line 350-356: I don't think the convex-upward model is necessarily applicable to Chinese Loess Plateau. Even mean soil water content higher than 20% was measured, this pattern was not observed in a previous study (https://doi.org/10.1016/j.geoderma.2011.02.008). Authors may want to discuss a bit more here.

**We will include this reference and rewrite the discussion as follows: "*The most widely reported model for describing the relation between spatial heterogeneity and mean soil moisture is a convex-upward parabola, with spatial variability peaking at intermediate values of soil moisture content (approximately 20%) (Brocca et al., 2010; Famiglietti et al., 2008; Jarecke et al., 2021; Peterson et al., 2019; Tague et al., 2010; Western et al., 2003). This convex parabola has been observed in loess catchments as well (Gao et al., 2011; Gao et al., 2015; Shi et al., 2014), where spatial variability peaked at soil moisture within 15%-20%. However, in a similar loess system, Hu et al. (2011) found that the spatial variability slightly increased with increasing soil moisture, even in wet conditions (20%-25%), indicating that a natural logarithmic curve might better describe the relationship between spatial variability and average soil moisture. In the Gutun catchment, the average soil*

moisture mainly concentrated between 5%-15%, which means we may only be observing the short rising segment of a convex parabola below the variability peak, or the middle section of a logarithmic curve.**"**

Line 373-374: again, this is not that obvious though this may be true. Please consider to improve the figure 7. Probably rather than showing point value, it would be good idea to mapping the whole area?

Although certain methods, such as Kriging interpolation, can map the soil moisture distribution for the entire catchment, they may generate artificial values, including strange ones in areas lacking monitoring sites. This would be misleading. Instead we prefer to present the actual measured values, which we believe are more reliable and informative. We will add an aspect layer as a base map into Fig. 7 to help illustrate the findings.

Line 405-406: the statistical analysis here can be misleading as less samples from gully than slope.

The correlation analysis was specifically based on monitoring data from the hillslope sites, excluding the gully areas. Therefore, our result indicates that there is no significant correlation between TWI and soil moisture patterns at the hillslope scale. We will clarify this point and highlight the "hillslope scale" in the revised manuscript: "*…We found no statistically significant correlation between TWI and the soil moisture patterns on the slopes for any soil depth, or averaged over the top 100 cm of the soils in each month. It is important to emphasize that we focus on the relationship between TWI or aspect with soil moisture patterns at the hillslope scale, excluding the gully. Soil moisture at the catchment scale is, however, markedly higher in the gully (Figs. 2-3), consistent with the high TWI values there.*"

Line 411-413: I would be cautious to draw this conclusion because gully was much wetter in this study.

We will emphasize the "hillslope scale" in the conclusion: "*Therefore, as a typical proxy of topography, TWI is probably not a suitable index for explaining the soil moisture pattern on the hillslopes in such systems (Dymond et al., 2021).*"

Line 426: the role of aspect in driving water variation was also documented in previous studies in the same areas. These papers need to be included in discussion.

We will include several related studies conducted in the loess plateau in L383: "*…leading to smaller differences in evaporation and thus more consistent soil moisture between the two slopes at the Gutun catchment. Hu et al. (2017) and Gao et al. (2016) similarly showed a pronounced impact of aspect on soil moisture patterns in other catchments in loess landscapes similar to ours.*"

References:

Hu, W., Shao, M., Han, F. and Reichardt, K., 2011. Spatio-temporal variability behavior of land surface soil water content in shrub-and grass-land. Geoderma, 162: 260-272.

Jia, X., Shao, M., Wei, X. and Wang, Y., 2013. Hillslope scale temporal stability of soil water storage in diverse soil layers. Journal of Hydrology, 498: 254-264.

Wang, Y., Shao, M., Zhu, Y. and Liu, Z., 2011. Impacts of land use and plant characteristics on dried soil layers in different climatic regions on the Loess Plateau of China. Agricultural and Forest Meteorology, 151: 437–448.

Wang, Y., Shao, M., Liu, Z. and Horton, R., 2013. Regional-scale variation and distribution patterns of soil saturated hydraulic conductivities in surface and subsurface layers in the loessial soils of China. Journal of Hydrology, 487: 13–23.